GEOLOGIC MAPPING OF GUSEV CRATER-MA'ADIM VALLIS REGION, MARS. R.O. Kuzmin[1], R. Greeley[2], R. Landheim[3], and N. Cabrol[3], [1]Vernadsky Institute, Russian Academy of Sciences, 117975, Kosygin Street 19, Moscow, Russia, [2]Dept. of Geology, Arizona State Univ., Tempe AZ 85287-1404, [3]NASA Ames Research Center, Space Science Division, Moffett Field, CA 94035-1000[3].

Introduction

Geological mapping of the Gusev Crater-Ma'adim Vallis region is part of a NASA program to investigate potential landing site areas on Mars. Two photomosaics at 1:500,000-scale (MTM sheets-15182 and 15187) and individual Viking images with resolution of 63-68 m/pixel were used as the base for the geologic mapping. The area is included in the Aeolis subquadrangle of Mars and is located in the transitional zone between the lowlands of the Elysium basin to north and oldest highland plateaus to the south. The 160 km diameter Gusev Crater and Ma'adim Vallis are located in the central part of the map area. The crater served as a long-term sedimentary basin for Ma'adim Vallis. In addition, an unnamed sedimentary basin (300 km in diameter) is located to the west of Gusev Crater. This basin accumulated sediments from both Ma'adim Vallis and other fluvial systems during Upper Noachian-Middle Amazonian periods.

Stratigraphy

The map units of the Noachian plateau and highland plains assemblage, and the Hesperian-Amazonian channel-lacustrine materials are subdivided on their morphologic characteristics and contact relations. All map units (exclusive of crater material) are divided into two broad categories: 1) plateau and plains materials of Noachian to Amazonian ages; 2) channel-lacustrine materials formed in the Hesperian-Amazonian periods. The relative ages of the units were established by stratigraphic relations and crater size frequency distributions.

Noachian System. The oldest units in the map area are of limited extent and are represented by mountainous material (Nm) and degraded crater rim material (Nrd). Unit Nm may consist of impact breccias and ancient volcanic massifs, formed in the period of high impact flux and uplifted later by faulting [1,6] to form long ridges or crustal blocks. The origin of the Nrd unit is unclear, but could be the result of impact or volcanic processes. The main plains and plateau-forming units of the period include cratered materials (Npl1), a subdued cratered unit (Npl2), and a modified cratered unit (HNpl3). These represent different stages of early reworking of highland crustal material by ground-water sapping [2], ground ice-magmatic interactions [3], and Ma'adim Vallis flooding and episodic flooding around lower Ma'adim Vallis due to fluvial activity. The walls of Ma'adim Vallis and Durius Valles cut a thick sequence of Noachian-Hesperian rocks, mapped as undivided material (unit HNw).

Hesperian System. Units of this age formed from: 1) multiple episodes of fluvial activity both on plateau plains (units Hchm and Hchd) and within Ma'adim Vallis and Durius Valles (unit AHch1); 2) deposition from water erosion and sheet wash of early volcanic material (unit Hpld); and 3) fluvio-lacustrine sedimentation within Gusev crater and crater basin (unit AHbf). Degraded channel material (unit Hchm) is found in places in the paleo-drainage system. The deposits of the degraded channel unit HNpl3 are found only around the west tributary of Durius Valles where they form branch-like patterns; the patterns resemble an ancient sedimentary delta which may have developed on the surface of a glacial sheet or frozen lake. Apparently after ice sublimation the delta deposits were left as positive relief features. Dissected plains material (unit Hpld) represents the dominant Hesperian unit and is found to the north and west of Gusev crater, superimposed mostly on the Npl1 unit. Unit Hpld is dissected by dense systems of straight grooves and narrow channels resulting from erosion. We suggest that the Apollinaris Patera units Ha3 and Ha4 [4] formed in Middle Hesperian. Intravalley deposition within Ma'adim Vallis and Durius Valles formed the upper level terraces of the valles (unit AHch1); crater statistics suggest a Late Hesperian-Early Amazonian age. Fluvial activity within Ma'adim Vallis and Durius Valles (corresponding to AHch1 unit formation) was responsible for the formation of the rough terrain material (unit AHbf) found in the eastern third of the Gusev crater floor and outside the crater. The unit forms a terrace inside Gusev crater and embays and superposes the Hpld and Npl1 units outside of the crater. Chaotic material (unit AHcht) is widespread within the crater basin and consists of densely spaced hills and mesas that become progressively broken up and isolated toward Apollinaris Patera. Formation of the unit started in Late Hesperian by the disintegration of Hpld and AHbf materials, possibly by melting of

ground ice and dissection by outflows from Ma'adim Vallis and Durius Valles.

Amazonian System. The units of this system include assemblages of highland plains (units Aps,Aml1-2,Amu,Arm and Asm) and channel-lacustrine materials in Gusev Crater and crater basin (units Ach2-3,Abf1-3,Agf1-2,Adfm,Aetpl, Aft and Achp). Smooth plain materials (unit Aps) formed mostly inside old craters during the Amazonian and may have resulted from fluvial, mass-wasting, and aeolian processes. Units Aml1-2 and Amu, which make up the Medusae Fossae Formation, occupy only a narrow zone on the northeastern edge of the map area and have been eroded by winds. These units have been suggested to be ash-flow tuffs [5], pyroclastic or aeolian materials [6], or paleopolar deposits [7]. The dune field material (unit Arm) formed as result of wind erosion of Aml1-2 units. Younger plains material on the map area (unit Asm) is represented by aeolian deposits in some large craters and occupies an extensive area in the center of Gusev crater. Evidence of Amazonian fluvial activity in the map area includes units Ach2 and Ach3, comprising the lower terraces and floor of Ma'adim Vallis respectively and the floor of Durius Valles (Ach2). The units are coeval with the ponding stages in Gusev Crater and crater basin in Lower-Middle Amazonian, represented by fluvio-lacustrine materials, Agf1-2 and Abf1-3. Flooding from Gusev Crater and Durius Valles might be responsible for the disintegration and dissection of unit AHcht. The fact that units Agf2 and Abf1-2 have tongue-like outlines and lobate fronts suggests that the last stages of flooding inside Gusev Crater and the crater basin occurred as debris flows from the mouth of the valles, perhaps accompanied by glacial processes. Massive and hilly deposits (unit Adfm) with lobate margins formed in Gusev Crater and in places on the plains unit HNpl3, and includes debris flow deposits. The etched plains material (unit Aetpl) covers a low-lying area in the center of the crater basin and is interpreted to result from water erosion of units Hpld,AHcht,Ahbf and Abf3, aided by ground-ice melting from geothermal heating or sapping by volcano-ground ice interactions. Similar processes may account for the fretted material (unit Aft) within the crater basin. The youngest flood-plain material (unit Achp) in the north-western edge of the map area apparently formed by sapping of the surface by water, percolated through both the AHch1 unit and permeable rocks of the Gusev crater rim.

Conclusion

Geologic mapping of the Gusev crater-Ma'adim Vallis region shows that during Late Noachian-Middle Amazonian periods the area was subject to multiple resurfacing from fluvial deposition associated with the Ma'adim Vallis and Durius Valles, perhaps associated with the Sirenum Fossae grabens and areas of chaotic terrains in Ariadnes Colles. The area is characterized by a diversity of geologic units formed throughout the history of Mars. Units are represented by ancient crustal materials, fluvial and fluvio-lacustrine materials, volcanic materials modified by water erosion, and modern aeolian deposits. Because of this diversity, the area is of high scientific interest for future Mars landings and sample-return missions. The long-term fluvio-lacustrine sedimentation within the map area give the region a high potential for meeting exobiologic and climate history objectives.

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